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STATUS OF MEDITERRANEAN FRUIT FLY RESEARCH^{1/}

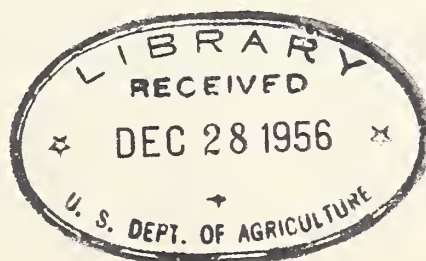
Mediterranean fruit fly investigations have been conducted in Hawaii by the federal government and territorial and private research groups almost continuously since the fruit fly was discovered there in 1910. Intensive research programs on this fruit fly have also been carried on in numerous Mediterranean countries, South America, Africa and Australia. The 1929-30 outbreak in Florida and the more recent Costa Rican infestation made additional contributions to our information.

The cooperative fruit fly research in Hawaii was greatly expanded in 1949 in response to the emergency situation created by the oriental fruit fly. Early emphasis in this research was on the oriental fruit fly, but new information on the Mediterranean fruit fly has also been accumulated. The research program in Hawaii involves the cooperative efforts of the U. S. Department of Agriculture, Hawaii Agricultural Experiment Station, Territorial Board of Agriculture and Forestry, Pineapple Research Institute, Hawaiian Sugar Planters' Experiment Station, and University of California Agricultural Experiment Station.

The excellent research accomplished by the Mexican Fruit Fly Laboratory in Mexico City has also added much to our knowledge of tropical fruit flies and their control.

The extensive resource of knowledge now available concerning the Mediterranean fruit fly is strongest in its biological phases but recent advances that appear to be highly significant have also been made in the development of lures, chemical control procedures, and commodity treatments.

^{1/} Prepared by L. D. Christenson, L. F. Steiner, and J. W. Balock, Entomology Research Branch, Agricultural Research Service, U.S.D.A., Honolulu, T. H. for presentation at Mediterranean fruit fly quarantine hearing, Washington, D. C., May 9, 1956.



BIOLOGY-ECOLOGY.--Extensive studies carried on throughout the world since the turn of the century have provided an impressive array of information on the life history and habits of the Mediterranean fruit fly and its ecological requirements. This appears to provide reasonably good biological support for control and quarantine programs that are being initiated in the new Florida Mediterranean fruit fly emergency, but undoubtedly there will still arise many questions which cannot be answered without further research. The fruit fly laboratory in Hawaii, where the Mediterranean fruit fly also occurs, will make available its informational and research resources and undertake any investigations that will contribute directly to the Florida campaign.

The movement habits of the Mediterranean fruit fly are still imperfectly known. Usually the adults seem to remain in locations with suitable hosts, yet there is also evidence of good capacity for dispersal, especially when no hosts are available. Additional information on flight habits is urgently needed. Recent improvements in Mediterranean fruit fly lures will provide much better opportunities for recovery of marked flies in the new studies that are contemplated.

Most of the Mediterranean fruit fly hosts in current lists appear to be supported by adequate field infestation data but in some of them only rare or accidental infestation has ever been reported. Continued efforts to resolve these marginal host problems, especially those involving economic crops, are desirable. Preferably studies should be related to fundamental research on host selection and relationships and the factors that determine suitability for larval development.

An important comparatively recent development in the fruit fly research has been the determination by the U. S. Department of Agriculture and University of

California Agricultural Experiment Station, in special bioclimatic cabinets of the areas in continental United States in which the fruit flies in Hawaii, including the Mediterranean fruit fly, might be expected to do well and achieve pest importance in the event of accidental introduction. Unfortunately for Florida, these cooperative studies showed conclusively that the Mediterranean fruit fly will do very well under winter conditions in Florida south of the 30th parallel. When simulated in the cabinets the winter of 1929-30 at Orlando, at the time of the previous infestation, provided entirely suitable conditions for survival and reproduction despite occasional freezing or slightly subfreezing temperatures. The bioclimatic cabinet data also indicated that summer temperatures in Florida are not apt to be critical from a survival standpoint although they will certainly accelerate development and probably shorten adult life. The Mediterranean fruit fly completed 10 successive generations in about a year's time in the Orlando cabinet while the oriental fruit fly was completing only 5. Yet the total number of Mediterranean fruit flies was only slightly higher numerically because of its much lower biotic potential.

The adverse effect of heavy rainfall on the Mediterranean fruit fly--this was not adequately known until the Costa Rica infestation declined from substantial pest proportions in May, 1955 to almost undetectable infestations on the Meseta Central after several weeks of unusually heavy daily rains--is not likely to be a factor in south Florida where, if our impression is correct, summer periods of rainfall are usually interspersed with ample periods of sunlight and other conditions favorable for fly activity. The extent to which heavy rainfall in itself may cause actual fly mortality is speculative. Probably more important are the conditions unfavorable for oviposition activity and when there is excessive moisture fruits often tend to rot and break down quickly before the flies can complete their development in them.

Another aspect of the biology of the Mediterranean fruit fly that needs investigation is concerned with nutrition and sources of essential nutrients available to the flies under field conditions. Currently production of experimental flies under laboratory conditions is good but difficulties frequently encountered strongly suggest that we don't know the best diets for these flies. Techniques for producing healthy Mediterranean fruit flies are of utmost importance because of the need for standard flies in experiments, and the potential importance of such methods in case mass production of parasites is required or research with eradication techniques involving sterile male releases continues to be promising and large-scale programs are undertaken. Information on sources of essential nutrients in the field may also be important because, if specific sources are indicated, new avenues of approach to control may be suggested.

CHEMICAL CONTROL.--The highly toxic phosphatic materials and chlorinated hydrocarbons which have been developed since World War II have opened up many new possibilities for eliminating fruit fly infestations.

During the first two years of the intensive oriental fruit fly investigations initiated in 1949 in Hawaii, area control experiments conducted on Lanai and Oahu demonstrated that large-scale applications of new insecticides such as DDT, DDT in combination with parathion, or aldrin alone, when applied by air or, in the case of DDT, in fog aerosols, will reduce Mediterranean fruit fly and oriental fruit fly infestations almost to the vanishing point. The results suggested that eradication of these flies with insecticides is feasible.

A significant development at the federal fruit fly laboratory in Honolulu was the discovery that a spray containing a phosphatic insecticide and protein hydrolysate will attract the oriental fruit fly, melon fly, or Mediterranean fruit fly and elicit strong feeding responses in them. The prior development of malathion, parathion and other phosphatic materials was essential for development of the new bait spray. Of equal significance was the University of

California discovery, in fundamental research, that certain enzymatic yeast hydrolysates contain nutrients essential for the development of sexual maturity in the oriental fruit fly.

With this new type of bait spray, containing parathion or malathion wettable powders, remarkably small amounts of toxicants per acre have given excellent protection from oriental fruit fly attack in extensive tests conducted during more than five years. The experiments soon demonstrated the new bait spray is also effective against the melon fly and Mediterranean fruit fly. Numerous growers in Hawaii are using these sprays with good success to prevent fruit fly injury to passion fruit or for protecting certain vegetable crops from fruit fly attack.

Attractiveness to fruit flies is an important attribute of the bait spray, but the feeding response which the protein material elicits, which even transcends ovipositional urge, permits control through stomach poison action at low dosages that can be applied to ripening fruits as close as 2 days before harvest without exceeding tolerances. Parathion is the most effective toxicant for use in these sprays, but malathion is also effective and usually the material of choice because of its low mammalian toxicity. Currently it is possible to recommend only a few protein hydrolysate baits. Not all are effective and some have high salt contents that are phytotoxic. Strangely enough, only the phosphatic insecticides have been effective in combination with protein hydrolysates, and only wettable powder formulations seem to work well. However, many of the other new insecticides are effective against fruit flies when used without the protein hydrolysates. When used alone from 3 to 4 times as much toxicant per acre is required, and an extended interval between application and harvest is required to avoid excessive residues.

The new bait sprays are sensitive to any foreign element that may repel the flies or counteract attractiveness of the bait in other ways. Not all of

the interfering elements are known but certain fungicides reduce or kill bait spray effectiveness and for this reason cannot be included in such sprays. Excessive natural sources of protein hydrolysates such as honey dew from aphids may interfere with bait spray effectiveness unless recommended amounts of bait are rigidly adhered to.

Numerous additional bait materials are awaiting test at the U. S. D. A. fruit fly laboratory in Honolulu. Some of these were prepared from various grain proteins especially for the tests in Hawaii by the Northern Utilization Research Laboratory. We are hopeful that comparatively cheap and even more effective bait ingredients may soon be available for use in these sprays.

Most of the many experiments with protein hydrolysate bait sprays have been conducted with fruit flies other than the Mediterranean fruit fly. Tests made with Mediterranean fruit fly indicate the bait sprays are effective against this fruit fly and it is our belief that they can be used in the present emergency with full confidence that proper schedules and applications will eliminate fly production in the treated areas.

Adequate information on the possible usefulness of systemic insecticides in an eradication campaign is not available. Experiments in Hawaii have shown that heavy applications of demeton may prevent Mediterranean fruit fly production in Jerusalem cherry for extended periods but much additional information on dosages, residue hazards, and effectiveness in a variety of plants is needed before sound recommendations can be made. Use of systemics suggest the interesting possibility that single heavy applications to wild or remote isolated hosts can be used to eliminate fly production for an entire crop.

Soil toxicants have been tested against other tropical fruit flies at both the Mexico City and Honolulu fruit fly laboratories, but not specifically against the Mediterranean fruit fly. Usually they fall short of 100% effectiveness. They also fail to give high kills of adults emerging from puparia already

in the soil at the time of treatment, and the adults are not restricted to the treated areas after they emerge. Soil toxicants may be important supplemental control agents under certain conditions and they can be counted on to reduce greatly the emergence of flies from larvae entering the soil to pupate if good distribution is achieved.

Another promising technique for Mediterranean fruit fly eradication involves release of sterile males, a procedure which has been used successfully to eliminate the screw worm fly in Curacao. However, the research on the use of this method has not yet reached the point where it could be used in the present emergency.

Enzymatic protein hydrolysates ammoniated with ammonium chloride are demonstrating strong attractiveness to both sexes of the Mediterranean fruit fly. The possibility that these may have direct control usefulness in traps is being investigated. This type of lure has also been recommended for use as a scouting method after extensive tests in Hawaii and Costa Rica demonstrated its superiority.

The marked progress in development of chemical control procedures for fruit flies has greatly reduced fear of fruit fly infestations but the need to eradicate incipient infestations is as great as ever. There is every reason for believing that the new tools which have been developed in the past decade will prove to be entirely effective in an eradication campaign.

COMMODITY TREATMENTS.--Intensive research to develop quarantine treatments for fresh fruits and vegetables infested with fruit flies has been in progress for many years. Prior to 1951 most attention was devoted to exploring possibilities for vapor-heat sterilization, cold storage, and methyl bromide fumigation. Since the discovery in 1950, by the U. S. Department of Agriculture and University of California, of the effectiveness of ethylene dibromide, application of this fumigant to as many of the fruit fly quarantine problems as possible has

been an important objective of studies conducted by the Federal government, with the Hawaii and California Experiment Stations contributing essential tolerance studies. In the last few years much investigation has also centered about the exciting possibilities of dips containing fumigants or other toxicants and evaluation of the effectiveness of ionizing irradiation from a cobalt 60 source in eliminating fruit fly introduction risk normally associated with fruit fly infested fresh fruits and vegetables.

A number of treatments have been approved and used at one time or another to permit movement of commodities infested by the Mediterranean fruit fly.

Cold Storage is effective but it has not come into extensive practical usage because of temperatures and holding periods required--ranging from 16 days at 36° F. down to 10 days at 32° F.--are not tolerated by many tropical or subtropical fruits and vegetables.

Vapor-heat Sterilization has been used extensively for treating grapefruit in Texas, and it is still the treatment of choice of papaya shippers in Hawaii because storage rots that affect shelf life are inhibited by the heat. In addition to citrus and papayas, vapor heat is approved only for bell pepper, egg plant, Italian squash, and tomatoes. Recent quick run-up innovations in which the fruit is heated evenly and quickly by saturated vapor until fruit centers reach 117° F. have streamlined the process considerably. Principal objections to vapor heat are the failure of many fruits and vegetables to tolerate the treatment and some loss of natural flavor and aroma in treated commodities.

Methyl bromide fumigation is approved for guava, papaya, bell pepper, bitter melon, cucumber, summer squash, string beans and tomatoes. The approved dosage is 2 lb. per 1000 cu ft. for 3½ hours at 80° F. Tolerance studies conducted by the University of California Agricultural Experiment Station have shown that most deciduous fruits with the exception of persimmons and plums probably

will tolerate this dosage but results from year to year have been highly variable. Most melons, squash, and tomatoes also tolerated the approved dosage but other vegetables were injured. Valencia and navel oranges, grapefruit, and lemons were injured when exposure to 2 lb. was extended beyond 2 hours.

Ethylene dibromide fumigation is approved as a treatment for the oriental fruit fly, melon fly, and Mediterranean fruit fly in papaya, cucumber, zucchini squash, bitter melon, and Cavendish banana. At first, only treatment of naked fruits was permissible. Later a schedule for wrapped and packaged papayas was developed. Recommendations for the use of ethylene dibromide fumigation have been based primarily on tests with oriental fruit fly-infested fruits and vegetables. Comparative tests with guavas and navel and Valencia oranges cage-infested by Mediterranean fruit flies indicated that the same dosage $\frac{1}{2}$ lb. for 2 hours at 70° F. for naked fruits--is also effective against this fruit fly, even though it is slightly more resistant to ethylene dibromide than the oriental fruit fly. Oranges and grapefruit are not affected by the $\frac{1}{2}$ lb. dosage but information on $1\frac{1}{2}$ lb. under package treatment conditions needs to be developed.

Recently the usefulness of ethylene dibromide has been extended to the citrus treatment problem in the lower Rio Grande Valley in Texas.

Ethylene dibromide does not provide a panacea for all fruit fly commodity treatment problems. Some fruits and vegetables are injured by effective dosages, and there may be differences in its effectiveness when used on different types of fruits. Failure of tolerated dosages and schedules of this and other fumigants to give adequate kill of infestations in avocados poses an urgent treatment problem which is now receiving major attention in the Hawaiian research. In the ethylene dibromide studies a dosage of $1\frac{1}{2}$ lb. ethylene dibromide per 1000 cu. ft. for 4 hours at 70° F. killed 99.94% of 79,724 oriental fruit fly eggs and larvae in avocados, but this falls short of desirable security standards.

More recent oriental fruit fly tests have suggested some promise for vacuum fumigation, 100% mortality of 13,857 eggs and larvae being obtained with $1\frac{1}{2}$ lb. for 2 hours at 70° F. under initial vacuum of 27" dropping to 20" at the end of the treatment. These two treatments represent the maximum dosages tolerated by any of the Hawaiian avocados. However, avocados vary greatly in their susceptibility to injury by ethylene dibromide and each variety should be tested to determine whether fumigation would be safe.

Aqueous dips containing small amounts of ethylene dibromide have shown much promise in extensive tests conducted in Hawaii during the past 3 years. A 20-minute 110-111° F., warm water dip containing 1 part ethylene dibromide in 20,000 parts water has given satisfactory control of 46,096 Mediterranean fruit flies and 26,275 oriental fruit flies in papayas. An 80° F. dip for 10 minutes at a dilution of 1 to 5,000 killed 100% of 21,841 oriental fruit flies and 99.96% of 25,638 Mediterranean fruit flies in papayas.

Although comparatively high dosages of ionizing irradiation from a cobalt 60 source have failed to kill fruit fly eggs or larvae in Hawaiian tests during the past 18 months, comparatively low dosages so affected the exposed stages that development beyond the pupal stage has not occurred. These findings present the fascinating possibility that a rapid irradiation treatment based on dosage-delayed mortality curves can be developed. An application for a strong cobalt 60 source is being prepared and we are hopeful it will be possible to pursue this promising lead to an early conclusion.

Fumigant screening studies have provided few interesting new materials in recent years. A program of candidate fumigant synthesis such as that now being followed in lure and insecticide studies is desirable. Other forms of radiant energy such as accelerated electrons or supersonics have not been promising, largely because of penetration difficulties. Numerous combination treatments involving heat, cold, fumigation, or dips have been tested on avocados

in Hawaii but few have shown real promise. The possibility that difficult problems such as that presented by avocado may be solved by combining the effectiveness of different types of treatments is one that cannot be neglected in commodity treatment research.

Little has been said about fumigant residue problems in treated fruits and vegetables. Continued use of ethylene dibromide will depend upon eventual setting of tolerances by the Food and Drug Administration. An intensive program to obtain acceptable residue data is currently underway.

The last decade has been a highly productive one from the standpoint of progress of commodity treatment research. We are looking to the future with full confidence that remaining problems will soon yeild to the new ideas and procedures that research will inevitably provide.

